MIDDLE POMERANIAN SCIENTIFIC SOCIETY OF THE ENVIRONMENT PROTECTION

Rocznik Ochrona Środowiska

Volume 21. Year 2019 ISSN 1506-218X 1061-1075

Environmental Protection in the Aspect of Preventing Collisions with Wild Boar, Roe Deer, Red Deer Based on Selected Railway Lines in Wielkopolska

Mateusz Iwiński[1], Adam Zydroń[1], Dariusz Kayzer[1], Janusz Dąbrowski[2]
[1]Poznań University of Life Sciences, Poland
[2]Koszalin University of Technology, Poland
[*]corresponding author's e-mail: mateusz.iwinski@up.poznan.pl

1. Introduction

Development of road and railway infrastructure results in an increased landscape fragmentation. Due to economic considerations and a lack of adequately conducted ecophysiographic studies or environmental impact analyses new investments in the transport infrastructure transect habitats where forest animals feed and live (Burdzik & Wojtas 2016, Iwiński et al. 2019). Newly designed transport networks are being constructed while attempting to ensure the longest possible straight stretches of these routes, as a result of which ecosystems are directly divided even when it is attempted to compensate for the process of their defragmentation by installing passive protection measures against animal intrusion (Stolarski & Żyłkowska 2011). The intent to develop transport networks facilitating ever increasing maximum design speeds has led to a greater probability of collisions. Animals moving in the area of modernised railway tracks, on which trains travel at speeds reaching 160 km/h need much more time to respond, thus a higher percentage of animals collide with approaching trains. The incidence of collisions is limited by the application of various protection methods. These include passive measures such as animal passages, fencing or even noise barriers as well as active measures, e.g. successfully used wildlife protective devices such as UOZ-1 using sounds of frightened animals as a deterrent (Werka et al. 2013). Despite assurances on 100% effectiveness of passive protection methods against animals, collisions are an inevitable element of transport networks and account for a significant percentage of all delays and exclusion of vehicles from operation.

Events involving game animals are relatively difficult to identify and categorise. The primary problem is related with the determination of causes for animal migration in areas of transport infrastructure. This paper presents identified factors affecting the frequency of collisions of big forest mammals with trains over selected fragments of five railway lines located in the Wielkopolska region. Spatial and statistical analyses were used to determine what elements of landscape subjected to fragmentation affect the probability of such collisions.

2. Review of literature

Development of various elements of transport infrastructure provides several advantages both to the society and economy (Badyda 2010). However, introduction of new elements into the existing landscape leads to negative effects, suffered by animals living in a given ecosystem (Burdzik & Wojtas 2016). Ecological barriers produced as a result of construction and modernisation of transportation networks generate negative ecological effects such as e.g. collisions between means of transport and migrating animals (Czarnecka 2016).

The phenomenon of natural migration corridors being transected by road infrastructure may be limited thanks to the development of animal crossings along newly constructed or modernised fragments of transportation networks or along those fragments at the greatest risk of collisions. The high number of animal passages constructed in Poland for forest animals is unique on the European scale (Nowacka 2014). Obviously it has been the effect of the intention to preserve forests, meadows or wetlands relatively little transformed by human activity, constituting natural habitats and feeding grounds for animals (Burdzik & Wojtas 2016). Despite the considerable number of animal passages constructed in Poland (2300 such structures) (Nowacka 2014) it is still advisable to investigate the effectiveness of their use, since many of them remain unused, primarily due to the inadequate parameters of these facilities (Burdzik & Wojtas 2016).

Based on the results of analyses conducted in the area of railway tracks we may indicate basic causes for collisions between vehicles and forest animals. These may include the intensity of traffic, the width and speed of vehicles, mobility of animals and technical parameters of railway tracks. As it has been observed (Olkowska et al. 2015), the lowest number of collisions seems to be recorded for narrow-gauge single-track lines with low design speeds, because migrating animals adequately early receive the stimulus preventing a collision. Similar observations indicate that traffic intensity and migratory activity of animals are the primary factors determining the incidence of such collisions (Rolandsen et al. 2011). In fact migratory behaviour of individual species varies greatly, which results in the need to conduct separate analyses. Wild boars typically colonise areas located in the vicinity of urbanised regions (Merino et al. 2009).

Frequent foraging in areas inhabited by humans, mainly in the suburbs of cities, is associated with high activity of animals along transport routes, which leads to a greater number of collisions (Jansen et al. 2007). A factor resulting in an increased probability of collisions is connected with increasing populations of wild animals and the adaptation of wild animals to vehicle traffic along with their perception of vehicles as constituting no threat (Dodd et al. 2007). Observations of animal behaviour seem to indicate that transport routes are no longer barriers for wild boars, while they are a significant limitation for red deer and for roe deer (Kušta et al. 2017).

Due to the high intensity of vehicle traffic acting as a barrier, a large number of vehicles travelling within a given stretch of the transport network may act on animals as a deterring stimulus preventing them from crossing the pavement (Seiler 2005). Similarly as roads, railway lines have a negative impact on the natural environment and constitute a barrier to migration of forest animals. However, in view of the relatively low traffic intensity (in comparison to roads and motorways) they are very often a part of the habitat inhabited by animals, which cross such barriers several times a day or even forage in grassy stretches, which by being mowed by road maintenance services are an excellent substitute for pastures (particularly for roe deer and hares) (Stolarski & Żyłkowska 2011). Analyses of relationships between traffic intensity and maximum design speeds indicate that for railways we may point to the tracks as constituting a barrier. The highest number of recorded tracks of even-toed ungulates was found in the buffer zone along stretches of railway tracks with the lowest traffic intensity, while the smallest number of traces of animal life may be observed along intensively used fragments of the transport network (Olkowska et al. 2015). In the case of railway tracks a factor determining the number of collisions involving animals is connected with the train speed. As indicated by Kulińska et al. (2017), fragments of the stretches with speeds of 40-50 km/h are characterised by the lowest number of events, since animals are able to respond promptly enough. In contrast, at speeds exceeding 100 km/h the time needed by foraging animals to respond is too long, thus leading to collisions, since they do not manage to leave the tracks (Stolarski & Żyłkowska 2014, Kulińska et al. 2017).

3. Study area

The Wielkopolskie province is located in central-western Poland and covers an area of 29 826.50 km². The relief is the result of two glaciations: the Saalian II glaciation, which formed a relatively uniform southern part of the province devoid of lakes, and the Würm glaciation responsible for the formation of the Pomeranian, Poznań and Gniezno Lake Districts. The Wielkopolskie province lies in the basin of the Warta river (88% drainage) as well as the basins of the

Barycz, Krzycki Rów and the Obrzyca. The northern part of the province is dotted by almost 800 postglacial lakes. Climatic conditions in the Wielkopolska are mild, with an average annual temperature of 8.2°C and mean annual precipitation total ranging from 500 to 550 mm (Liberacki & Szafrański 2013). However, in the eastern part of the province we can observe progressing soil droughts commonly associated with the term of "steppe development" caused by deforestation and intensive operation of brown coal mines (Dzięciołowski 1979).

The primary function of land use in the Wielkopolska region is connected with agriculture, with agriculturally utilised areas covering 65% of the total area. The predominant soils in the Wielkopolska are rusty podsolic soils (60%), lessivé and brown soils (20%) and wetland soils. Almost 26% of the province area is covered by forests (766.2 thousand hectares as of 31.12.2012, according to Central Statistical Office). The main forest complexes include the Zielonka and Notecka Forests. Due to the urbanisation pressure and suburbanisation processes (Szczepański et al. 2013) almost 58% forests have been covered by various forms of legal protection (Zydroń & Bober 2013).

Selected fragments of railway tracks are lines varying in terms of their technical parameters, surrounding areas and the technological standard. Route 356 of the Poznań – Bydgoszcz line is a non-electrified segment of a single-track railway line of 128 km in length, since 2004 used only within the boundaries of the Wielkopolskie province. In 2011 it was modernised in the Poznań – Wągrowiec section (52 km) and it is used by the Koleje Wielkopolskie railways. The maximum design speed in that segment is 120 km/h. Line 356 runs in the vicinity of areas of considerable nature value (the Zielonka Forest, the Warta river valley) (Stachowski 2008). The line is used by passenger trains carrying approx. 3.6 thousand passengers daily. The Wielkopolska segment of railway line no. 351 is a railway trunk line within route E 59. It is a double-track, fully electrified railway route with maximum design speeds reaching 150 km/h. Its Wielkopolska segment runs through the Puszcza Notecka Forest and crosses the Warta river. Its larger part is located in agriculturally utilised areas. The analysed fragment of line 271 links Poznań with Wrocław. It is one of the most intensively used segments of the railway tracks in Poland. The double-track, fully electrified Wielkopolska segment, in recent years significantly modernised is located at a close distance to Poznań and runs through the buffer zone of the Wielkopolski National Park, along the Warta river and further through areas intensively utilised by agriculture. This line is characterised by maximum speeds reaching 160 km/h. A part of trunk line no. 3 links Warszawa and Kunowice divided into two sections (from Kunowice to Poznań called line 357 and from Poznań to Warszawa) for the purposes of the study. The travelling speeds reach 160 km/h. The line is a double-track and fully electrified segment equipped with passive wildlife protective measures such as overpasses and underpasses in the route. It runs mainly through intensively utilised agricultural areas.

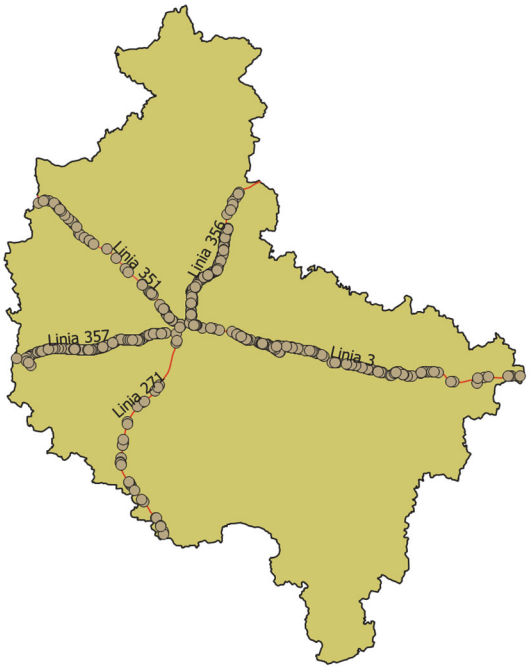

Fig. 1. Map of analyzed railway lines with accident locations

4. Empirical material and research methods

Analysed empirical material comprised data recorded by services of the Polish Railway Lines on collisions between trains and animals, which rapidly entered the tracks or tried to cross them. The database collected from PLK PKP S.A covered 6 884 events in the period from 1.01.2007 to 15.06.2017. In view of the selected study area the data were subjected to a preselection process, which limited these events to those recorded for lines located within the Wielkopolskie province. The total number of collisions in the Wielkopolska region was 1269 events (18.5% all observations), for the final analysis a total of 602 events were selected, reported for 5 sections of the railway tracks being the transportation trunk for the Wielkopolskie province linking Poznań with neighbouring provincial capitals. The length of the analyzed sections was less than 503 km The empirical material was supplemented following the adopted methodology with attributes used in statistical analyses. Based on the available location data per 1 km^2 the following types were shown: forests, agriculturally utilised areas, surface waters and urbanised areas. The research methodology comprised two stages: spatial and statistical analyses. Spatial analyses were performed using GIS open-source software (QGIS ver. 2.12.2 Lyon). Vector information on the reported collisions

(PLK PKP S.A.) was integrated with open-layer data (OpenStreetMap, mapa.plk-sa.pl) concerning land use (forests, agriculturally utilised areas, surface waters, urbanised areas) and networks of railway tracks (WMS, vector data accessed from NaturalEarth). Using tools of spatial analyses (heating maps) it was decided to select for further analyses five segments of railway tracks linking the Poznań Main Station with the boundaries of the Wielkopolskie province (lines 3, 271, 351, 356). Based on the methodology proposed by Malo et al., (2004) the selected fragments of railway tracks were divided into equal segments of 1 km. Applying geoprocessing (QGIS, QChainage) the railway tracks were divided and buffer zones of 1 km^2 were established for them. Next the following attributes were determined for them: the number of events (ranging from 0 to 17, where n = 571), the presence of a specific land use function in the buffer zone: surface waters, forest complexes, agriculturally utilised areas and urbanised areas. The presence of a given element of landscape in the buffer zone was indicated in the dichotomic scale (1 when a given function was observed in the buffer zone, 0 when it was absent) using spatial nodes (QGIS, NNJoin) and the distances between vector layers were exported to the CSV file as source material for statistical analyses.

The independence of the variation in the levels of two quantitative variables may be verified using the chi-square test as a test of trait independence (Zydroń & Kayzer 2015). Let us assume that we are investigating independence of events in terms of differences in the number of incidents divided according to analysed animal species (roe deer, wild boar, red deer). Let us assume that events are assigned to separate groups in terms of the division into species. The obtained distribution of numbers forms the so-called four-fold table (Farreas et al. 2005). At such defined divisions verification was conducted for the hypotheses that in the analysed experimental sample the classification of events to investigated groups varies depending on the animal species. One of the aims of the analyses was to indicate whether a change in the frequency of events involving animals of individual species (wild boar, roe deer, red deer) is influenced by the distribution of populations in the levels of analysed factors. The distinguished factor is characterised by the size of the fraction of collisions involving animals in the investigated buffer zone (0 – the event was not recorded, 1 – the event was recorded).

5. Results

Analyses of the collected data on the events show that the greatest percentage of events 68% (391 events) are collisions involving roe deer. Slightly below 21% (118 events) were caused by collisions with wild boars. Red deer rapidly entering the tracks accounted for the lowest percentage share (11%, 62 events) in all the observed collisions.

Based on the results presented in the Table (Tab. 1) it was observed that the frequency of events involving the identified animal species is significantly influenced by buffer zones characterised by the presence of developed areas. It was found that 66% among all collisions with red deer, 77% involving roe deer and 83% with wild boars recorded in buffer zones comprising areas, in which buildings are found.

Table 1. Four-plot table including analyzed species

	forests		waters		developed areas		agricultural land	
	0	1	0	1	0	1	0	1
Wild boar	13	105	35	83	20	98	83	35
Red deer	7	55	21	41	21	41	46	16
Roe deer	45	346	110	281	90	301	259	132
total	65	506	166	405	131	440	388	183
χ^2	0.0224		0.880		0.659		1.94	
p	0.99		0.64		0.04		0.38	

When investigating the other factors no dependencies were found between their levels and the frequency of events involving animals of individual species. Approximately 89% all events with the participation of animals were recorded in the buffer zone comprising forested areas, 70% in the buffer zone with surface waters, while 30% in the buffer zone containing utilised agricultural areas (Table 1).

Analyses of events involving wild boars showed that the greatest number of collisions was recorded in the area of railway tracks located in forest complexes as well as developed areas and near surface waters. Analyses of collisions with wild boars given in four-fold tables identified pairs of variables, which are interdependent (Table 2). It was recorded that the number of collisions depends on the location connected with the simultaneous presence of forested areas and surface waters. It was observed that 67% collisions took place in the buffer zones, in which surface waters were simultaneously found with forests, while 22% events – in the case of the presence of forests and absence of surface waters. Additionally, at the absence of forests it was recorded that 8% events occurred in

the situation when buffer zones contained no surface waters, while 3% – at the presence of surface waters.

The next pair of dependent variables was connected with the buffer zones with urbanised areas and surface waters. It was found that 55% events involving wild boars took place in the buffer zones comprising both surface waters and developed areas, while 28% events were reported in the buffer zones comprising urbanised areas and no identified surface waters. In turn, 15% observations were connected with the buffer zones with surface waters at the absence of building development (Table 2).

Moreover, when investigating the other pairs of buffer zones for events involving wild boars the results were not found to be significantly dependent on the interaction of both factors. Analyses of the results obtained for the buffer zones connected with arable fields and forests it was observed that the number of events is significantly higher for the presence of forests and absence of arable fields than at the simultaneous occurrence of both buffer zones.

Table 2. A contingency table for wild boar events

		waters		developed areas		agricultural land	
		0	1	0	1	0	1
forests	0	9	4	1	12	8	5
	1	26	79	19	86	75	30
	χ^2	10.96		0.889		0.542	
	p	0.001		0.34		0.46	
agricultural land	0	23	60	15	68		
	1	12	23	5	30		
	χ^2	0.510		0.251			
	p	0.45		0.62			
developed areas	0	2	18				
	1	33	65				
	χ^2	4.46					
	p	0.03					

Analysis of events involving roe deer indicated (Table 3) that the greatest number of collisions was recorded in the buffer zones containing forests (346), built-up areas (301) and waters (281).

Table 3. A contingency table for roe deer events

		waters		developed areas		agricultural land	
		0	1	0	1	0	1
forests	0	23	22	15	30	24	21
	1	87	259	75	271	235	111
	χ^2	13.3		3.05		3.79	
	p	<0.001		0.08		0.05	
agricultural land	0	76	183	62	197		
	1	34	98	28	104		
	χ^2	0.556		0.367			
	p	0.46		0.54			
developed areas	0	24	66				
	1	86	215				
	χ^2	0.124					
	p	0.72					

In the analyses of events involving roe deer variability related to the buffer zones with forested areas and surface waters as well as forested areas and arable land was observed to be interdependent. It was found that 66% all events with roe deer were reported at the simultaneous presence of forested areas and surface waters. In turn, at the presence of surface waters and absence of buffer zones related to forests the number of events with roe deer decreased by 2/3. Moreover, in the situation when surface waters and forests were not found simultaneously in the buffer zones or waters were found at the absence of forested areas the share of reported events was approx. 6% each. When investigating the other pairs of distinguished variables in terms of the frequency of events involving roe deer no interdependence was observed between their levels (Table 3.). Analyses of interactions between forests and fields showed the highest number of events for the buffer zones of forests at the absence of arable fields.

Events with the participation of red deer accounted for the lowest percentage of events involving large game. Only 7 such events were recorded when the buffer zones contained no forested areas (Table 4). Analyses of events caused by red deer indicated one pair of dependent variables, i.e. the presence of surface waters and forested areas in the buffer zones.

Table 4. A contingency table for red deer events

		waters		developed areas		agricultural land	
		0	1	0	1	0	1
forests	0	5	2	2	5	4	3
	1	16	39	19	36	42	13
	χ^2	4.97		0.094		1.20	
	p	0.03		0.75		0.27	
agricultural land	0	16	30	17	29		
	1	5	11	4	12		
	χ^2	0.066		0.758			
	p	0.75		0.38			
developed areas	0	8	13				
	1	13	28				
	χ^2	0.253					
	p	0.62					

The largest number of events (63%) took place at the simultaneous presence of surface waters and forested areas in the buffer zones. A much higher number of collisions with red deer were recorded in the situation when the buffer zones contained forests at the absence of surface waters compared to the buffer zones containing no forests at the presence of surface waters. In the case when none of these land use types were found in the buffer zone as little as 8% collisions were recorded. No pairs of dependent variables were observed among the other variables (Table 4).

6. Discussion of results

The highest number of collisions in the areas of the analysed segments of railway tracks was observed for roe deer (391), with wild boars ranking second (118), while the lowest number of accidents was caused by red deer (62). The frequency of collisions with animals (with no division into species) on railroad tracks was influenced by the simultaneous presence of forest complex, developed areas and surface waters in these buffer zones. Obtained research results are partly consistent with those presented by Jansen et al. (2007) and Merino et al. (2009), who observed increased migration of wild boars in urbanised areas and areas affected by suburbanisation; however, their data did not concern deer species.

The simultaneous presence of two factors increases the probability of collisions. The presence of buffer zones including forested areas overlapping with buffer zones with surface waters, as well as built-up areas overlapping with surface waters results in an increased frequency of collisions involving wild boars. This is confirmed by studies by Malo (2004) and Seiler (2005), who observed an increased number of collisions in areas of high biodiversity, as well as an increased number of such observations in areas covered by forests. However, they stated that the presence of built-up areas reduces the frequency of such events. Collisions with roe deer and red deer are characterised by two and one pair of dependent variables. In those cases the highest number of events took place at the simultaneous presence of forests and surface waters in the distinguished buffer zones, while in the case of roe deer it was in the buffer zones where agriculturally utilised areas and forest complexes were simultaneously present.

Based on the conducted studies we may formulate a thesis that the locations where collisions involving forest animals are reported are dependent on the animal species. This may be observed between red deer and wild boars, with differences in the pairs of dependent variables. For this reason studies on factors affecting the frequency of events involving forest animals should be conducted for each species separately. Based on the conducted investigations it may be stated that spatial planning may reduce the frequency of collisions. Analyses of individual segments of the railway tracks using contingency tables we may specify, in which areas a higher frequency of events will be recorded and thus the application of passive and active methods preventing collisions with wild animals may be considered in these fragments of the railway lines.

The publication was co-financed within the framework of Ministry of Science and Higher Education programme as „Regional Initiative Excellence" in years 2019-2022, Project No. 005/RID/2018/19.

References

Badyda, A. J. (2010). Zagrożenia środowiskowe ze strony transportu. *Nauka, 4*, 115-125.

Burdzik, R., Wojtas, K. (2016). Wpływ rozbudowy systemów transportowych na ekosystemy i dziką faunę, Zeszyty naukowe Politechniki Śląskiej, Series: Transport 70 1835. Budownictwo i architektura, 15(1) 249-257

Czarnecka, W. (2016). Prędkość i jej wpływ na wypadki na drogach z udziałem zwierząt. Wydział Zarządzania ruchem, Zarząd dróg i mostów w Lublinie. *Budownictwo i Architektura, 15(1),* 249-257.

Dodd, N. L., Gagnon, J. W., Boe, S., Schweinsburg, R. E. (2007) Assessment of elk highway permeability by using global positioning system telemetry. *Journal of Wildlife Management, 71*, 1107-1117.

Dzięciołowski, W. (1979). *Środowisko glebotwórcze i gleby niziny wielkopolskiej.* Roczniki Gleboznawcze, XXX(1). Warszawa.

Farreas, V., Riera, P., Mogas, J. (2015). Does gender matter in valuation studies? Evidence from three forestry applications. *Forestry, 78(3).* 239-248.

Iwiński, M., Zydroń A., Chwiałkowski C., Dąbrowski T. (2019). The Use of a Camera Trap System for Monitoring the Movement of Forest Animals Through the Wildlife Crossing in Napchanie. *Rocznik Ochrona Środowiska, 21*, 157-166

Jansen, A., Luge, E., Guerra, B., Wittschen, P., Gruber, A. D., Loddenkemper, C. (2007). Leptospirosis in urban wild boars, Berlin, Germany. *Emerging infectious diseases, 13*, 739-742.

Kulińska, E., Wojtynek, H., Budzik, R. (2017). Wypadki z udziałem zwierząt w transporcie drogowym i kolejowym w Polsce. *Autobusy, 6*.

Kušta, T. Keken, Z., Jezˇek, M., Holá, M., Šmíd, P. (2017). The effect of traffic intensity and animal activity on probability of ungulate-vehicle collisions in the Czech Republic. *Elsevier Safety Science 91*, 105-113.

Liberacki, D., Szafrański, Cz. (2013).Tendencje zmian położenia zwierciadła wody gruntowej w wybranych zlewniach na obszarze Puszczy Zielonka. *Rocznik Ochrona Środowiska, 15*, 2425-2436.

Malo, J., Suárez, F., Díez, A. (2004). Can we mitigate animal-vehicle accidents using predictive models? *Journal of Applied Ecology, 41*, 701-710

Merino, M. L., Carpinetti, B. N., & Abba, a. M. (2009). Invasive mammals in the national parks system of Argentina. *Natural Areas Journal, 29*, 42-49.

Nowacka, D. (2014). Wpływ inwestycji drogowych na zwierzęta – działania minimalizujące, *Budownictwo i architektura 13(1)*, 63-73.

Olkowska, E., Szymankiewicz, K., Sękiewicz, M. (2015). *Ekspertyza dotycząca wpływu linii kolejowych na zwierzęta oraz szlaki migracji dla projektów inwestycyjnych z perspektywy 2014-2020*. Part 1: ssaki, z wyjątkiem nietoperzy, etap III. Warszawa.

Rolandsen, C., Solberg, E, Herfindal, I, Van Moorter, B, Sæther, B-E. (2011). Large-scale spatiotemporal variation in road mortality of moose: is it all about population density? *Ecospehere, 2*. 113. Doi: 10.1890/es11-00169.1

Seiler, A. (2005). Predicting locations of moose-vehicle collisions in Sweden. Journal of Applied Ecology, 42, 371–382.

Stachowski, P., (2008). Miejscowe planowanie i zagospodarowanie przestrzenne na przykładzie terenu w otulinie Parku Krajobrazowego „Puszcza Zielonka". *Rocznik Ochrona Środowiska, 10*, 575-592.

Stolarski, M., Żyłkowska, J. (2011). Ochrona zwierząt jako istotny element procesu inwestycyjnego podczas budowy i modernizacji linii kolejowych. *Problemy kolejnictwa, 153*.

Stolarski, M. Żyłkowska, J. (2014). Wypadki z udziałem zwierząt w transporcie kolejowym 2014, *Transport kolejowy, Transport i komunikacja, 3*.

Szczepański, P., Pyszny, K., Zydroń, A. (2013). Analiza zróżnicowania stopnia szczegółowości ustaleń polityk przestrzennych wybranych gmin aglomeracji poznańskiej. *Rocznik Ochrona Środowiska, 15*, 2767-2779.

Werka, J., Wasilewski, M., Krauze-Gryz, D., Jasińska, K. (2013). *Monitoring urządzeń do ochrony zwierząt* (uoz–1). Sprawozdanie za okres od grudnia 2007 do grudnia 2012 roku.

Zydroń, A., Bober, Ł. (2013). Opracowanie koncepcji zalesień dla gminy Tarnowo Podgórne. *Rocznik Ochrona Środowiska, 15*, 2942-2961.

Zydroń, A., Kayzer, D. (2015). Podnoszenie świadomości społeczeństwa o nowych metodach wyceny wartości przyrody Willingness to Pay oraz Willingness to Accept na przykładzie Wielkopolskiego Parku Narodowego, *Bogucki Wydawnictwo Naukowe*, Poznań.

Abstract

Collisions with forest animals constitute a considerable percentage of all events recorded for railway lines. Due to the development of infrastructure and higher technical parameters of tracks, accidents involving forest animals cause considerable economic losses and lead to significant delays in railway service. Appropriate management of areas neighbouring transport networks as well as application of both active and passive methods preventing animals from suddenly entering the road may limit a further increase in the number of such events and reducing negative environmental effects due to animal mortality. The paper presents an analysis whether and if so, which elements of landscape affect the frequency of collisions involving forest animals and whether by properly managing and securing these areas there is a possibility to prevent animal intrusion on communication networks. Using spatial analyses in the GIS environment (spatial nodes, topological relationships) as well as statistical analyses (contingency tables) it was indicated which pairs of factors determine an increase in the frequency of events involving roe deer, red deer and wild boars. It was proposed to apply the 0.1 system to determine the incidence of observed collisions in the buffer zone characterised by a given management function (forested areas, surface waters, arable land, urbanised areas). When analysing the database on collisions of the Polish State Railways providing information on 561 collisions recorded in the years 2007-2016 as well as cartographic materials publicised as open-layers it was shown that an increase in the frequency of collisions involving animals treated jointly, with no division into individual species, is influenced by the presence of developed areas in the buffer zones adjacent to railway tracks. In turn, an analysis of animal species participating in these events shows a certain similarity in the case of deer (roe deer and red deer). For these species one identical pair of mutually dependent variables was observed, i.e. surface waters and forested areas. Additionally, for collisions with roe deer another pair of dependent attributes was found, i.e. forested areas and agriculturally utilised areas. For wild boars an increase was observed in the frequency of events in the buffer zones, where surface waters were found together with forests and connected with urbanised areas. In the case of analyses concerning collisions with roe deer an interdependence was observed between two pairs of variables – forested areas and surface waters, and forested areas and agriculturally utilised areas. Red deer accounted for the smallest percentage of all collisions and for them one pair of mutually dependent variables involved buffers comprising surface waters and forested areas. Results of these studies confirmed the need to conduct analyses for each species separately. It was observed that the character of sites, where collisions involving individual even-toed ungulate species were recorded, depends on the specific nature of a given species. Moreover, these studies showed that by appropriate management of areas adjacent to railway

infrastructure provided by spatial planning, especially through the use of line protections we may reduce the frequency of collisions. It was observed that the proposed analytical methods (statistical and spatial) facilitate realisation of proposed research aims and can serve as a tool in planning the location of devices against the incursion of forest animals, which would reduce the negative environmental effects caused by animal mortality on railroad tracks.

Keywords:
spatial planning, ecological barriers, landscape fragmentation, railways, infrastructure and the environment

Ochrona środowiska w aspekcie przeciwdziałania kolizjom z udziałem zwierzyny leśnej na przykładzie wybranych linii kolejowych w Wielkopolsce

Streszczenie

Kolizje z udziałem zwierzyny leśnej stanowią znaczny odsetek wśród wszystkich zdarzeń obserwowanych na liniach kolejowych. Rozwój infrastruktury i wyższe parametry techniczne torów skutkują, że wypadki z udziałem zwierząt leśnych powodują znaczne straty ekonomiczne i są przyczynami znacznych opóźnień rozkładowych. Odpowiednie gospodarowanie terenami graniczącymi z sieciami transportowymi oraz stosowanie aktywnych i pasywnych metod ochrony przed wtargnięciem zwierzyny, może zapobiegać wzrostowi liczby zdarzeń i ograniczaniu negatywnych skutków środowiskowych spowodowanych śmiertelnością zwierzyny. W artykule poddano analizie czy i jakie elementy krajobrazu wpływają na częstość kolizji z udziałem zwierzyny leśnej oraz czy odpowiednio gospodarując i zabezpieczając te tereny istnieje możliwość zapobiegania wtargnięciom zwierzyny na sieci komunikacyjne. Wykorzystując analizy przestrzenne w środowisku GIS (złączenia przestrzenne, relacje topologiczne) oraz statystyczne (tablice kontyngencji) wskazano jakie pary czynników warunkują zwiększenie częstości zdarzeń z udziałem saren, jeleni i dzików. Zaproponowano wykorzystanie systemu 0,1 dla określania występowania zaobserwowanej kolizji w buforze charakteryzującym się daną funkcją zagospodarowania (tereny leśne, wody powierzchniowe, grunty orne, tereny zurbanizowane). Analizując bazę danych o kolizjach Polskich Linii Kolejowych zawierających 561 kolizji zaobserwowanych w latach 2007-2016 oraz materiały kartograficzne udostępniane na warunkach licencyjnych open-layers wskazano, że na wzrost częstości kolizji z udziałem zwierząt bez podziału na gatunki ma wpływ występowanie w buforze przylegającym do linii kolejowych terenów zabudowanych. Analizując gatunki zwierząt biorących udział w zdarzeniach, stwierdzono pewne podobieństwo dla jeleniowatych (sarny i jelenie). Wskazano dla nich jedną taką samą parę zmiennych zależnych od siebie w postaci terenów wód powierzchniowych i terenów leśnych. Dodatkowo dla kolizji z udziałem sarny zanotowano występowanie drugiej pary zależnych atrybutów w postaci terenów leśnych i gruntów użytkowanych rolniczo. Dla dzików zaobserwowano wzrost częstości zdarzeń w buforach, gdzie jednocześnie występowały wody powierzchniowe zestawione z lasami oraz połączone z terenami zurbanizowanymi. W przypadku analiz

dla kolizji z udziałem sarny, wskazano współzależność pomiędzy występowaniem dwóch par zmiennych – terenów leśnych i wód powierzchniowych oraz terenów leśnych i gruntów użytkowanych rolniczo. Jelenie stanowiły najmniejszy odsetek wszystkich kolizji i wskazano dla nich jedną parę zmiennych od siebie zależnych w postaci buforów zawierających wody powierzchniowe oraz tereny leśne. Wyniki badań potwierdziły konieczność prowadzenia analiz dla każdego gatunku z osobna. Zauważono, że charakter miejsc w jakim występują kolizje z udziałem poszczególnych gatunków parzystokopytnych zależy od specyfiki zwierzyny. Ponadto badania wskazały, że poprzez odpowiednie gospodarowanie terenami przyległymi do infrastruktury kolejowej w postaci planowania przestrzennego, a zwłaszcza poprzez stosowanie zabezpieczeń liniowych można ograniczać częstość występowania kolizji. Zauważono, że zaproponowane metody analiz (statystycznych i przestrzennych) umożliwiają realizację postawionych celów badawczych i mogą służyć jako narzędzie w planowaniu lokalizacji urządzeń przeciw wtargnięciu zwierzyny leśnej co pozwoliłoby na ograniczenie negatywnych skutków środowiskowych wywołanych śmiertelnością zwierząt na torach kolejowych.

Słowa kluczowe:
planowanie przestrzenne, bariery ekologiczne, fragmentaryzacja krajobrazu,
linie kolejowe, infrastruktura i środowisko